

Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education  
June 2007  
Advanced Level Examination



**PHYSICS (SPECIFICATION A)**  
**Practical (Units 5–9)**

**PHAP**

Monday 21 May 2007 1.30 pm to 3.15 pm

<p><b>For this paper you must have:</b></p> <ul style="list-style-type: none"> <li>• a calculator</li> <li>• a pencil and a ruler.</li> </ul>
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For Examiner's Use			
Question	Mark	Question	Mark
1			
2			
Total (Column 1)		→	
Total (Column 2)		→	
TOTAL			
Examiner's Initials			

Time allowed: 1 hour 45 minutes

**Instructions**

- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **both** questions.
- Answer questions in the spaces provided.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**

- The maximum mark for this paper is 30.
- The marks for questions are shown in brackets.
- *A Data Sheet* is provided on pages 3 and 4. You may wish to detach this perforated sheet at the start of the examination.
- You are expected to use a calculator where appropriate.
- You are advised to spend no more than 30 minutes on Question 1.

**Data Sheet**

- A perforated *Data Sheet* is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- You may wish to detach this sheet before you begin work.

## Data Sheet

Fundamental constants and values				Mechanics and Applied Physics		Fields, Waves, Quantum Phenomena	
Quantity	Symbol	Value	Units				
speed of light in vacuo	$c$	$3.00 \times 10^8$	$\text{m s}^{-1}$	$v = u + at$		$g = \frac{F}{m}$	
permeability of free space	$\mu_0$	$4\pi \times 10^{-7}$	$\text{H m}^{-1}$	$s = \left(\frac{u+v}{2}\right)t$		$g = -\frac{GM}{r^2}$	
permittivity of free space	$\epsilon_0$	$8.85 \times 10^{-12}$	$\text{F m}^{-1}$	$s = ut + \frac{at^2}{2}$		$g = -\frac{\Delta V}{\Delta x}$	
charge of electron	$e$	$1.60 \times 10^{-19}$	$\text{C}$	$v^2 = u^2 + 2as$		$V = -\frac{GM}{r}$	
the Planck constant	$h$	$6.63 \times 10^{-34}$	$\text{J s}$	$F = \frac{\Delta(mv)}{\Delta t}$		$a = -(2\pi f)^2 x$	
gravitational constant	$G$	$6.67 \times 10^{-11}$	$\text{N m}^2 \text{kg}^{-2}$	$P = Fv$		$v = \pm 2\pi f \sqrt{A^2 - x^2}$	
the Avogadro constant	$N_A$	$6.02 \times 10^{23}$	$\text{mol}^{-1}$	$\text{efficiency} = \frac{\text{power output}}{\text{power input}}$		$x = A \cos 2\pi ft$	
molar gas constant	$R$	8.31	$\text{J K}^{-1} \text{mol}^{-1}$	$\omega = \frac{v}{r} = 2\pi f$		$T = 2\pi\sqrt{\frac{m}{k}}$	
the Boltzmann constant	$k$	$1.38 \times 10^{-23}$	$\text{J K}^{-1}$	$a = \frac{v^2}{r} = r\omega^2$		$T = 2\pi\sqrt{\frac{L}{g}}$	
the Stefan constant	$\sigma$	$5.67 \times 10^{-8}$	$\text{W m}^{-2} \text{K}^{-4}$	$I = \sum mr^2$		$\lambda = \frac{\omega s}{D}$	
the Wien constant	$\alpha$	$2.90 \times 10^{-3}$	$\text{m K}$	$E_k = \frac{1}{2} I\omega^2$		$d \sin \theta = n\lambda$	
electron rest mass	$m_e$	$9.11 \times 10^{-31}$	$\text{kg}$	$\omega_2 = \omega_1 + \alpha t$		$\theta = \frac{\lambda}{D}$	
(equivalent to $5.5 \times 10^{-4}u$ )				$\theta = \omega_1 t + \frac{1}{2} \alpha t^2$		$n_2 = \frac{\sin \theta_1}{\sin \theta_2} = \frac{c_1}{c_2}$	
electron charge/mass ratio	$e/m_e$	$1.76 \times 10^{11}$	$\text{C kg}^{-1}$	$\omega_2^2 = \omega_1^2 + 2\alpha\theta$		$n_2 = \frac{n_2}{n_1}$	
proton rest mass	$m_p$	$1.67 \times 10^{-27}$	$\text{kg}$	$\theta = \frac{1}{2} (\omega_1 + \omega_2)t$		$\sin \theta_c = \frac{1}{n}$	
(equivalent to 1.00728u)				$T = I\alpha$		$E = hf$	
proton charge/mass ratio	$e/m_p$	$9.58 \times 10^7$	$\text{C kg}^{-1}$	$\text{angular momentum} = I\omega$		$hf = \phi + E_k$	
neutron rest mass	$m_n$	$1.67 \times 10^{-27}$	$\text{kg}$	$W = T\theta$		$hf = E_1 - E_2$	
(equivalent to 1.00867u)				$P = T\omega$		$\lambda = \frac{h}{p} = \frac{h}{mv}$	
gravitational field strength	$g$	9.81	$\text{N kg}^{-1}$	$\text{angular impulse} = \text{change of angular momentum} = Tt$		$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$	
acceleration due to gravity	$g$	9.81	$\text{m s}^{-2}$	$\Delta Q = \Delta U + \Delta W$		<b>Electricity</b>	
atomic mass unit	$u$	$1.661 \times 10^{-27}$	$\text{kg}$	$\Delta W = p\Delta V$		$\epsilon = \frac{E}{Q}$	
(1u is equivalent to 931.3 MeV)				$pV^\gamma = \text{constant}$		$\epsilon = I(R+r)$	
<b>Fundamental particles</b>				$\text{work done per cycle} = \text{area of loop}$		$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$	
<i>Class</i>	<i>Name</i>	<i>Symbol</i>	<i>Rest energy</i>	$\text{input power} = \text{calorific value} \times \text{fuel flow rate}$		$R_T = R_1 + R_2 + R_3 + \dots$	
			/MeV	$\text{indicated power as (area of } p-V \text{ loop)} \times (\text{no. of cycles/s}) \times (\text{no. of cylinders})$		$P = I^2 R$	
photon	photon	$\gamma$	0	$\text{friction power} = \text{indicated power} - \text{brake power}$		$E = \frac{F}{Q} = \frac{V}{d}$	
lepton	neutrino	$\nu_e$	0	$\text{efficiency} = \frac{W}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$		$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$	
		$\nu_\mu$	0	$\text{maximum possible efficiency} = \frac{T_H - T_C}{T_H}$		$E = \frac{1}{2} QV$	
		electron	$e^\pm$	0.510999			$F = BI l$
mesons	pion	$\mu^\pm$	105.659			$F = BQv$	
		$\pi^\pm$	139.576			$Q = Q_0 e^{-t/RC}$	
		$\pi^0$	134.972			$\Phi = BA$	
baryons	kaon	$K^\pm$	493.821				
		$K^0$	497.762				
		proton	$p$	938.257			
	neutron	$n$	939.551				
<b>Properties of quarks</b>							
<i>Type</i>	<i>Charge</i>	<i>Baryon number</i>	<i>Strangeness</i>				
u	$+\frac{2}{3}$	$+\frac{1}{3}$	0				
d	$-\frac{1}{3}$	$+\frac{1}{3}$	0				
s	$-\frac{1}{3}$	$+\frac{1}{3}$	-1				
<b>Geometrical equations</b>							
arc length = $r\theta$							
circumference of circle = $2\pi r$							
area of circle = $\pi r^2$							
area of cylinder = $2\pi rh$							
volume of cylinder = $\pi r^2 h$							
area of sphere = $4\pi r^2$							
volume of sphere = $\frac{4}{3} \pi r^3$							

$$\text{magnitude of induced emf} = N \frac{\Delta\Phi}{\Delta t}$$

$$I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$$

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

### Mechanical and Thermal Properties

$$\text{the Young modulus} = \frac{\text{tensile stress}}{\text{tensile strain}} = \frac{F}{A} \frac{l}{e}$$

$$\text{energy stored} = \frac{1}{2} Fe$$

$$\Delta Q = mc \Delta\theta$$

$$\Delta Q = ml$$

$$pV = \frac{1}{3} Nmc^2$$

$$\frac{1}{2} mc^2 = \frac{3}{2} kT = \frac{3RT}{2N_A}$$

### Nuclear Physics and Turning Points in Physics

$$\text{force} = \frac{eV_p}{d}$$

$$\text{force} = Bev$$

$$\text{radius of curvature} = \frac{mv}{Be}$$

$$\frac{eV}{d} = mg$$

$$\text{work done} = eV$$

$$F = 6\pi\eta rv$$

$$I = k \frac{I_0}{x^2}$$

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

$$\lambda = \frac{h}{\sqrt{2meV}}$$

$$N = N_0 e^{-\lambda t}$$

$$T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

$$R = r_0 A^{\frac{1}{3}}$$

$$E = mc^2 = \frac{m_0 c^2}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

$$l = l_0 \left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}$$

$$t = \frac{t_0}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

### Astrophysics and Medical Physics

Body	Mass/kg	Mean radius/m
Sun	$2.00 \times 10^{30}$	$7.00 \times 10^8$
Earth	$6.00 \times 10^{24}$	$6.40 \times 10^6$

$$1 \text{ astronomical unit} = 1.50 \times 10^{11} \text{ m}$$

$$1 \text{ parsec} = 206265 \text{ AU} = 3.08 \times 10^{16} \text{ m} = 3.26 \text{ ly}$$

$$1 \text{ light year} = 9.45 \times 10^{15} \text{ m}$$

$$\text{Hubble constant } (H) = 65 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

$$M = \frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$$

$$M = \frac{f_o}{f_e}$$

$$m - M = 5 \log \frac{d}{10}$$

$$\lambda_{\text{max}} T = \text{constant} = 0.0029 \text{ m K}$$

$$v = Hd$$

$$P = \sigma AT^4$$

$$\frac{\Delta f}{f} = \frac{v}{c}$$

$$\frac{\Delta \lambda}{\lambda} = -\frac{v}{c}$$

$$R_s \approx \frac{2GM}{c^2}$$

### Medical Physics

$$\text{power} = \frac{1}{f}$$

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \text{ and } m = \frac{v}{u}$$

$$\text{intensity level} = 10 \log \frac{I}{I_0}$$

$$I = I_0 e^{-\mu x}$$

$$\mu_m = \frac{\mu}{\rho}$$

### Electronics

#### Resistors

Preferred values for resistors (E24)  
Series: 1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2  
2.4 2.7 3.0 3.3 3.6 3.9 4.3 4.7 5.1 5.6 6.2  
6.8 7.5 8.2 9.1 ohms  
and multiples that are ten times greater

$$Z = \frac{V_{\text{rms}}}{I_{\text{rms}}}$$

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$$

$$C_T = C_1 + C_2 + C_3 + \dots$$

$$X_C = \frac{1}{2\pi f C}$$

### Alternating Currents

$$f = \frac{1}{T}$$

### Operational amplifier

$$G = \frac{V_{\text{out}}}{V_{\text{in}}} \quad \text{voltage gain}$$

$$G = -\frac{R_f}{R_1} \quad \text{inverting}$$

$$G = 1 + \frac{R_f}{R_1} \quad \text{non-inverting}$$

$$V_{\text{out}} = -R_f \left( \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right) \quad \text{summing}$$

**Turn over for the first question**

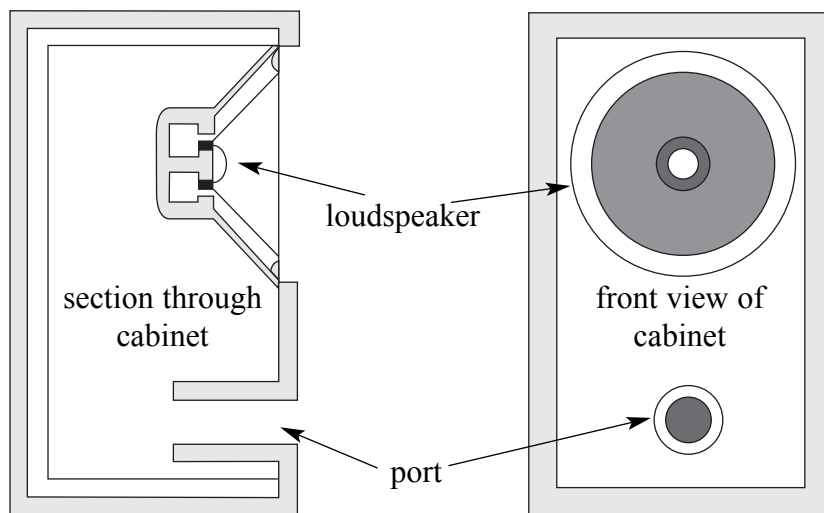
**Turn over ▶**

Answer **both** questions.

You are advised to spend no more than 30 minutes on Question 1.

- 1 It is common to find a loudspeaker mounted in a ‘bass reflex’ cabinet in which the cabinet is sealed except for a port below the loudspeaker. The port is a circular opening in the front of the cabinet with a round tube extending back into the box, as shown in **Figure 1**.

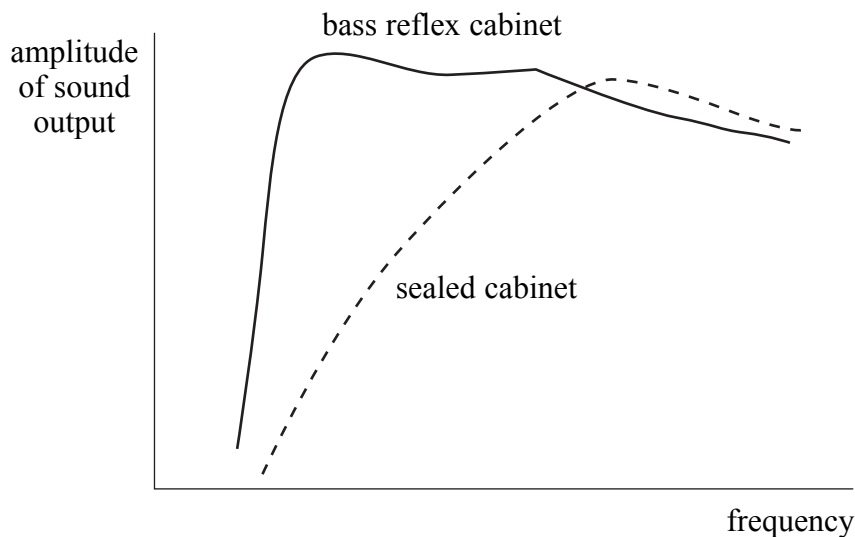
**Figure 1**



Putting a loudspeaker on its own in a sealed cabinet eliminates significant resonance and interference problems but this leads to poor efficiency in the bass part of the frequency-response curve for the loudspeaker. The inclusion of a port in the bass reflex cabinet significantly improves the response of the loudspeaker at lower frequencies.

**Figure 2** compares the response of a loudspeaker in a bass reflex cabinet with that of a loudspeaker in a sealed cabinet.

**Figure 2**



Design an experiment that a student could perform to discover how **one key dimension** of the port influences the frequency-response of a bass reflex loudspeaker.

You should assume that the normal laboratory apparatus used in schools and colleges is available, as is a loudspeaker mounted in a sealed box that the student may modify. A range of cylindrical piping is also made available to the student.

- Identify the quantities you intend to measure and explain how you will measure them.
- Explain how you propose to use your measurements to evaluate the performance of the loudspeaker as the dimension of the port is varied. You may wish to draw a diagram to illustrate this part of your answer.
- List any factor(s) you will need to control and explain how you will do this.
- Identify any difficulties you might encounter in obtaining reliable results and explain how these could be overcome.

Write your answers to Question 1 on **pages 8 and 9** of this booklet.

*(8 marks)*

**Turn over ▶**

Lined writing area with horizontal dotted lines.



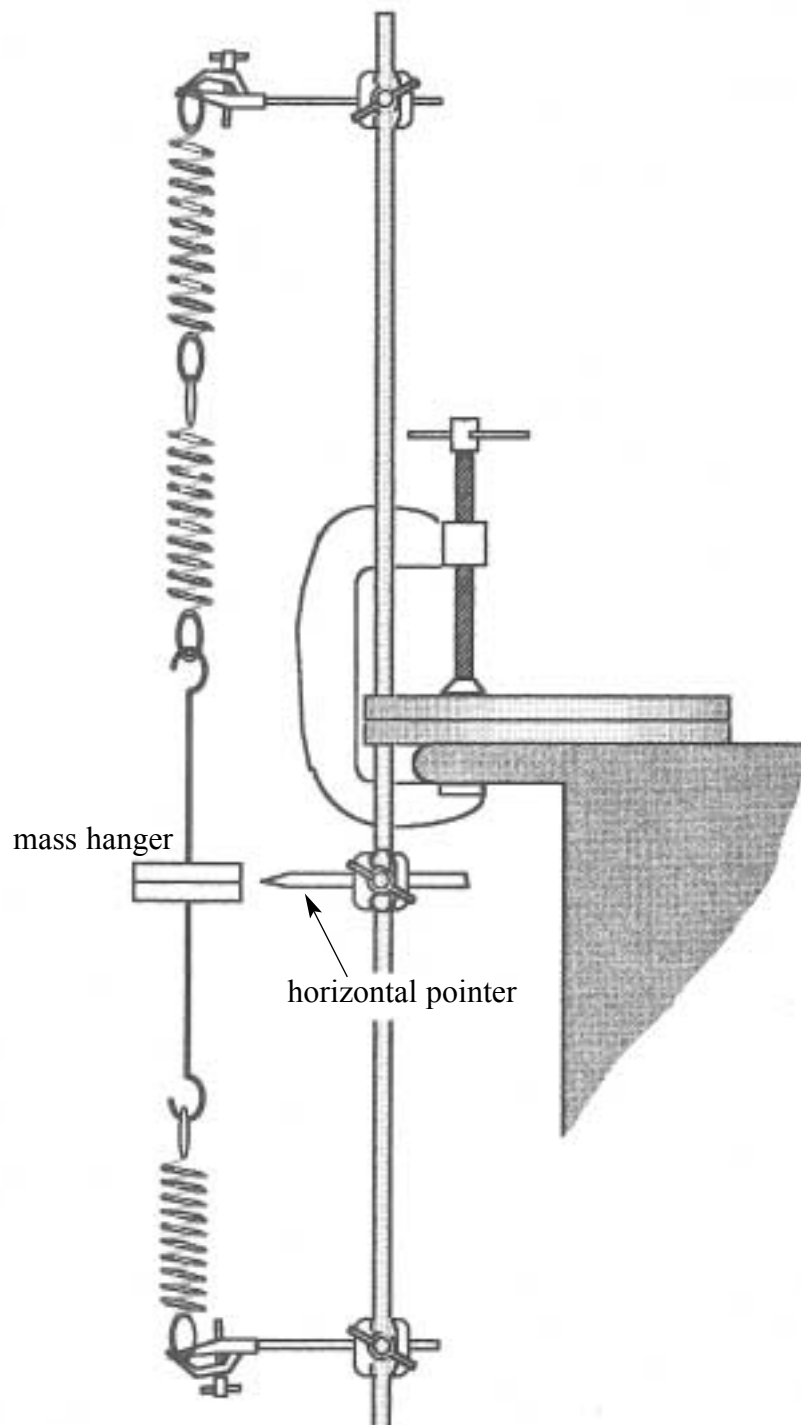
Blank writing area with horizontal dotted lines.

- 2 You are to investigate the properties of a system consisting of a variable mass suspended between three vertical springs.

**No description of the experiment is required.**

- (a) Check and if necessary adjust the position of the horizontal pointer until it is level with the middle of the mass hanger, as shown in **Figure 3**.

**Figure 3**



You are provided with a number of 100 g slotted masses. Use sufficient slotted masses to determine accurately  $\mu$ , which is the vertical deflection produced per kg of mass **added** to the hanger.

Give a suitable unit with your result for  $\mu$ .

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$$\mu = \dots\dots\dots$$

(1 mark)

- (b) Place a mass,  $m$ , of 100 g on the mass hanger. Adjust the position of the horizontal pointer until it is level with the middle of the mass hanger.

Vertically displace and then release the mass hanger so that the system performs small amplitude oscillations in a vertical line.

Make suitable measurements to determine  $T$ , the period of the oscillations.

You should use the horizontal pointer as a fiducial mark.

Repeat the procedure to find  $T$  for larger values of  $m$ . Each time adjust the position of the fiducial mark until it is level with the middle of the mass hanger.

Record all your measurements and observations below.

(4 marks)

Turn over ►

- (c) Plot a graph with  $T^2$  on the vertical axis and  $m$  on the horizontal axis.  
Tabulate the data you will plot on your graph below.

(8 marks)

- (d) Measure the gradient,  $G$ , of your graph and evaluate  $\frac{G}{\mu}$ .

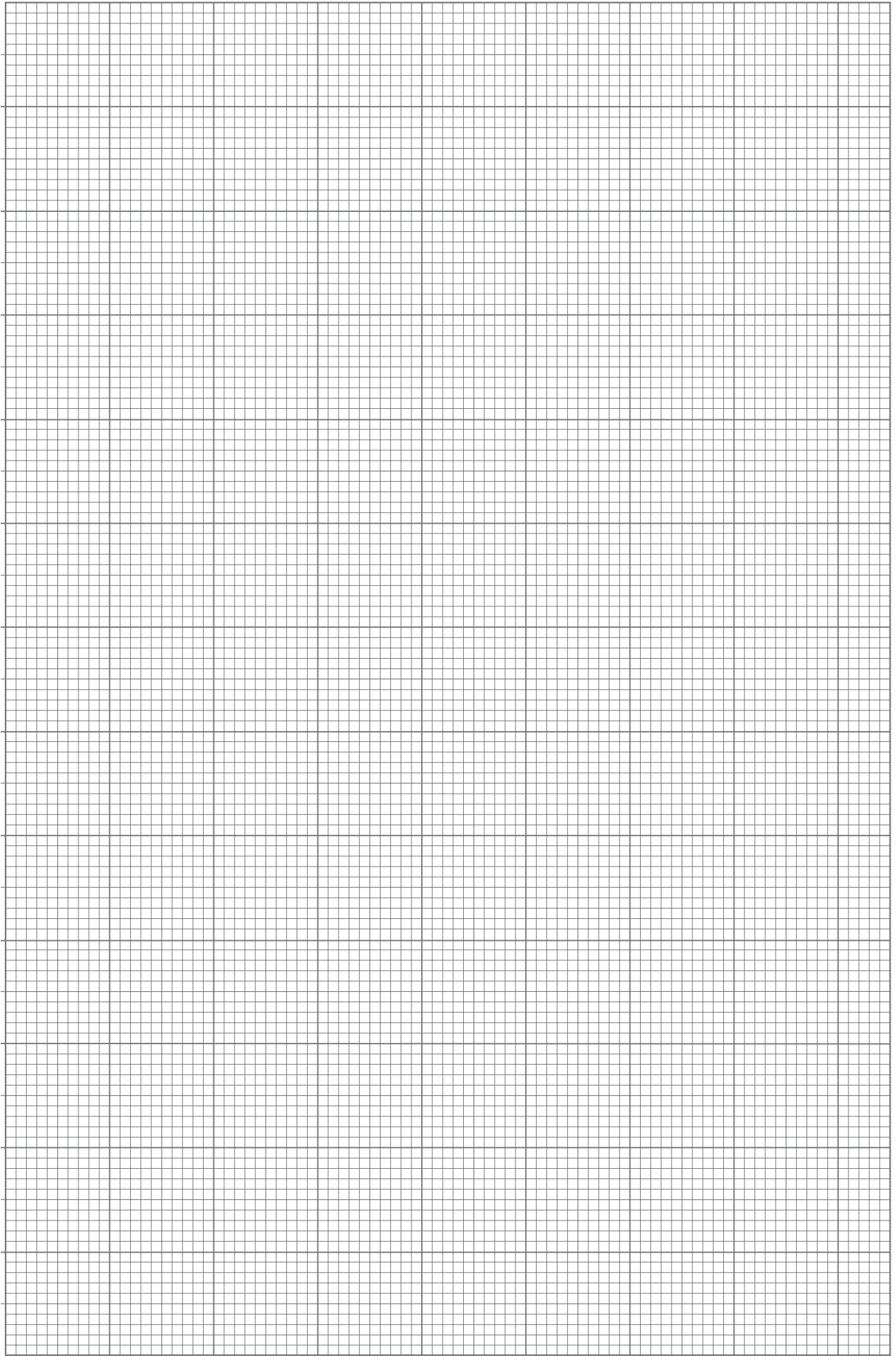
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$$\frac{G}{\mu} = \dots\dots\dots$$

(3 marks)



**Turn over ▶**

- (e) (i) Other than the use of the fiducial mark, list **three** precautions you took to reduce uncertainty in your measurements of  $T$ .

1 .....

2 .....

3 .....

- (ii) A student uses a data logger to eliminate human error from the timing measurements. Outline briefly what the student should do and how the data obtained could be used to find  $T$ .

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- (iii) A student performs the experiment with the lowest spring removed so the mass hanger is suspended freely. At a certain value of  $m$ , the spring-mass system begins to swing from side to side like a pendulum and the vertical motion becomes indistinct and difficult to measure. What physical phenomenon is responsible for the behaviour of the system that the student observes and how does the arrangement that you used avoid this problem?

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(6 marks)

**END OF QUESTIONS**

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